

WHISPER GEN®

Personal Power Station

INSTALLATION AND COMMISSIONING MANUAL

**Model: PPS16
3000 and 7000 series**

Configurations: 12V
 24V
 Diesel
 Kerosene
 Marine
 Land based



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**WHISPERGEN PPS16 Personal Power Station
Installation and Commissioning Manual**

Revision 080801

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INTRODUCTION

The WhisperGen

The WhisperGen is a unique personal power station providing cogeneration of heat and electrical energy. The WhisperGen is capable of charging and managing a lead-acid battery bank to provide a DC electrical power supply. It also provides heat energy in the form of hot coolant for space heating and domestic hot water generation.

For further information about how the WhisperGen works, refer to the PPS16 User's Manual.

Checklists for Installation and Commissioning of the WhisperGen are included in this manual to help ensure all services are properly connected before starting the WhisperGen, and that the WhisperGen is operating correctly.

Fuel

This manual applies to WhisperGen PPS16s which use:

- diesel, or
- kerosene.

The WhisperGen PPS16 burner and software are fuel specific. Do not run a diesel engine on kerosene, or a kerosene burner on diesel.

Voltage

This manual applies to WhisperGen PPS16s for the following nominal battery voltage:

- 12 Volt; and
- 24 Volt.

Configuration

This manual applies to WhisperGen PPS16s with the following configurations

- Marine – marine heat exchanger included
- Land based – marine heat exchanger not included.

WHISPERGEN INSTALLATION CHECKLIST

To validate the authorised agent's warranty for the WhisperGen the installer shall:

- install the WhisperGen as per the instruction manual
- complete the installation checklist in full.
For checkpoints which are not applicable for this installation enter "n/a".
- send a copy of the installation checklist to your authorized WhisperGen agent.

WhisperGen Engine Serial number	
Date of installation	
Installer:	Full name: Address: Phone: Fax: E-Mail:
Owner:	Name: Address: Phone: Fax: E-Mail:
Address of installation, or home shipyard of boat:	Name: Address: Phone: Fax: E-Mail:
Details of boat, (marine installations).	Type and size of vessel: Location of WhisperGen in vessel:

Before you install the WhisperGen			
	Read and understand the PPS16 User's manual.		
	Attend the WhisperGen installation course.		
	Read, understand, and comply with the relevant local authority regulations which apply to this installation.		
	Read, understand and comply with the Recreational Craft Directive 94/25/EC , issued by the Council of the European Community.		
	Read the Enable Starts warning.		

Page	Task	Details	Complete (✓)
Unpacking and mounting the WhisperGen			
1	The WhisperGen is unpacked. All parts and the installation pack are complete, and on site.		
1	The WhisperGen is mounted in a position which is: <ul style="list-style-type: none"> • clean and dry; and • with sufficient ventilation. 		
1	The WhisperGen is securely bolted in position.		
4	The WhisperGen is pressurised with nitrogen gas to 22 – 24 bar cold, (25°C).		

Plumbing the coolant circuits			
5	The exhaust heat exchanger is fitted, and bolted to the burner.		
6	The primary coolant circuit is plumbed using tubing which: <ul style="list-style-type: none"> • has an inside diameter of between 19mm and 30mm; • is rated for continuous operation at 1.5 bar at 100°C; • has as few bends as possible; and • has no sharp bends or kinks. 		
9	The primary coolant pump is mounted directly below the coolant tank.		
9	For series circuits, a self-bleeding header tank is installed at the highest point in the circuit, and the primary coolant circuit is self-bleeding of air.		

Page	Task	Details	Complete (✓)
9	The minimum distance between the top of the WhisperGen and the outlet from the header tank is 100mm.		
9	The volume of the header tank is at least 5% of the total volume of coolant in the circuit.		
9	The distance between the self-bleeding header tank and the coolant circulation pump is no more than 300mm.		
10	The inlet and outlet for the secondary coolant circuit is: <ul style="list-style-type: none"> • at least 2 metres apart • not connected to the inlet and outlet of another system 		
10	The inlet and seawater pump are under the water line by a minimum of 200mm at all times .		
12	The control panel is mounted in a dry position and the communication cable is connected.		
11	All connections from power sources and loads, except the battery, are to the battery side of the WhisperGen isolating switch.		
11	All connections from power sources and loads, except the battery, are to the non-battery side of the current shunt.		
11 and APP. B and C.	A deep-cycle lead acid or gel battery with a minimum capacity of 200 ampere hours for 12V systems; and 100 ampere hours for 24V systems is connected with: <ul style="list-style-type: none"> • the positive lead connected to the positive terminal of the battery bank via an isolating switch and a battery fuse or circuit breaker; and • the negative lead connected to the negative battery terminal in series with the supplied current shunt. 		
APP. B	The battery cable size is a minimum of 35mm ² .		
APP B.	The maximum run length for the battery cable is: <ul style="list-style-type: none"> • 4 metres for 12V; or • 8 metres for 24V. 		

Page	Task	Details	Complete (✓)
16	The wiring is connected according to the wiring diagram supplied with the WhisperGen.		
17	A good quality corrosion inhibitor, suitable for aluminium, and other components of the system, has been used in the primary coolant circuit.		
17	The primary coolant circuit has been bled of air, and the coolant is flowing at a minimum rate of 6 litres per minute.		
17	The primary coolant circuit has no leaks.		
18	The secondary coolant circuit has been bled of air, and the coolant is flowing at a minimum rate of 4 litres per minute.		
18	The secondary coolant circuit has no leaks.		

Setting up the fuel system			
20	For marine installations, the fuel line installation where applicable, complies with the Recreational Craft Directive 94/25/EC and marine regulations.		
20	The fuel line: <ul style="list-style-type: none"> • has an inside diameter of between 2.5mm and 3.5 mm; and • is a maximum of 8m in length. 		
20	The fuel pump is: <ul style="list-style-type: none"> • mounted in an upright position at the fuel tank; • downstream of a small inline fuel filter; • a maximum of 200mm from the fuel tank; • level to, or below the bottom of the fuel tank; • soft-rubber mounted. 		
20	The vertical range of the fuel tank relative to the base of the WhisperGen is +2m, -1.25m.		
21	The fuel system has been bled.		
21	The fuel fittings are not leaking.		
21	The fuel flow rate is $10\text{cc} \pm 1.5\text{cc}$ per minute at the connector to the evaporator.		

Setting up the exhaust system			
	The exhaust pipe: <ul style="list-style-type: none">• is short with few bends		
34	The exhaust outlet: <ul style="list-style-type: none">• is fitted with a weather protection cowling made from a suitable material;• will always have a slope of at least 10 degrees relative to the horizon;• will not be submerged at any time;• is not connected to any other outlets.		
34	The exhaust system is self draining of condensate under all conditions and condensate drains: <ul style="list-style-type: none">• run from all points in the exhaust where condensate is likely to be trapped;• use a drain tube with a minimum inside diameter of 10mm; and• have air traps fitted.		
35	Fresh water at 1.5 to 6 bar is connected to the fresh water inlet for exhaust heat exchanger flushing.		

1. Transporting the WhisperGen

The WhisperGen shall be transported:

- upright;
- bolted to a pallet and protected with a wooden cover labeled “Fragile”, and “No stack”;
- separated from lead acid batteries;
- with the exhaust heat exchanger unbolted from the burner, and clamped to the enclosure base;
- depressurised – see page 4 for details.

2. Unpacking the WhisperGen

Removal of the pallet base is optional. See this page, Mounting the WhisperGen.

To unpack the WhisperGen:

1. *Unscrew the screws around the bottom of the crate.*
2. *Carefully lift the cover vertically from the WhisperGen.*
3. *Unpack the spare parts and installation pack from beside the WhisperGen.*

3. Mounting the WhisperGen

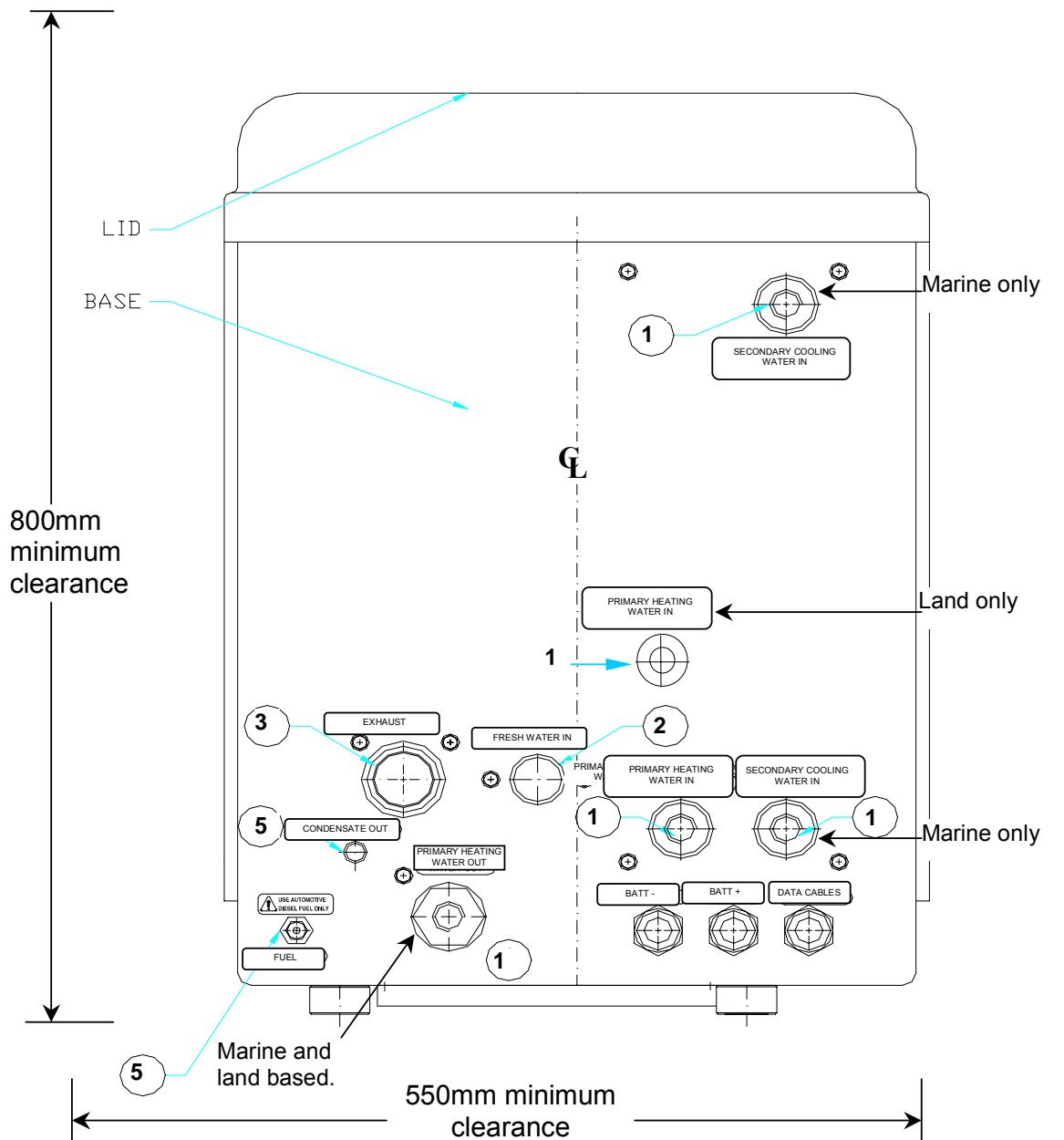
See **Figure 1**: Minimum Clearances, Services, and Mounting bolts layout, pages 2 and 3.

The WhisperGen shall be mounted in a location which:

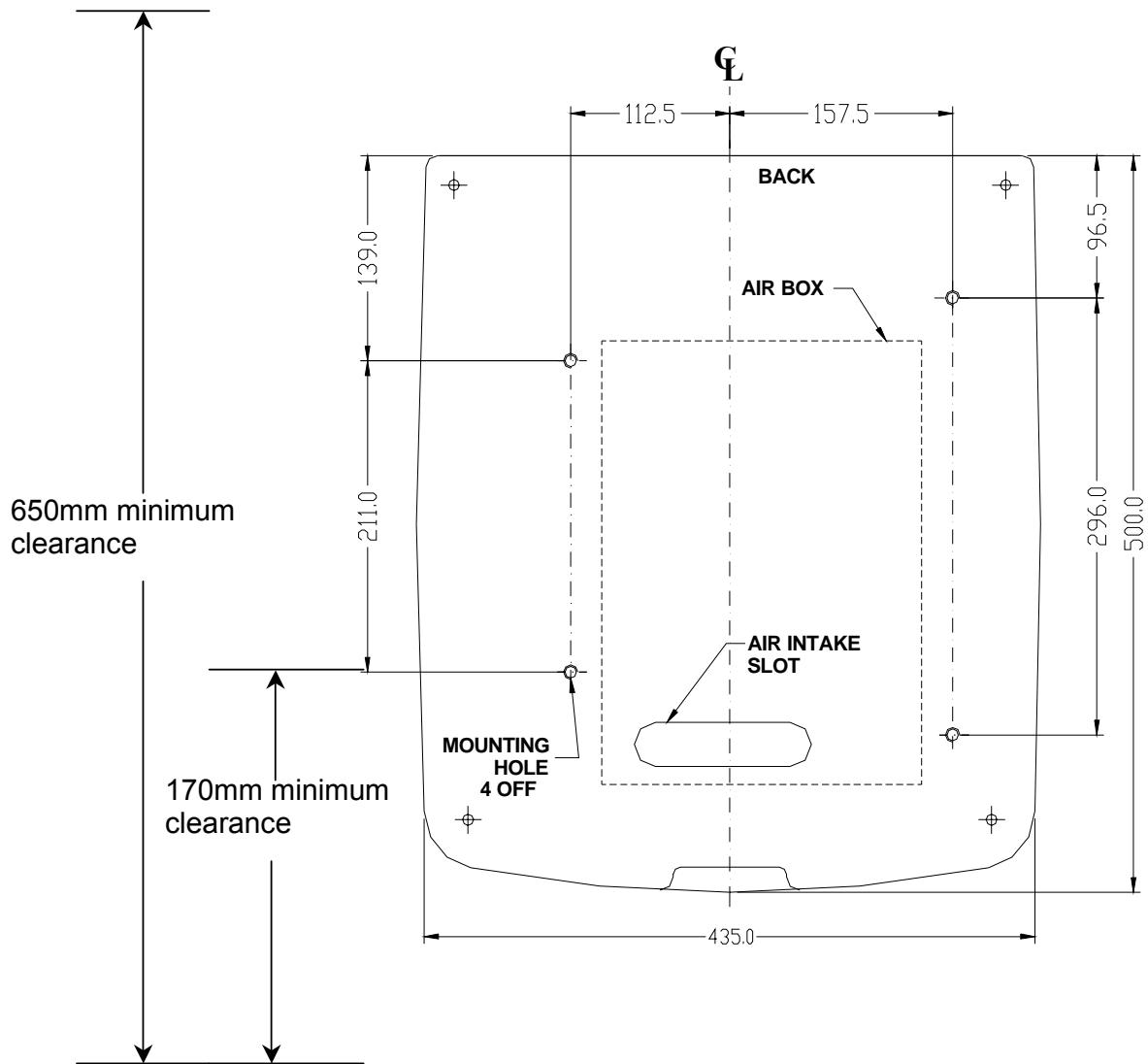
- is clean and dry;
- is not airtight; and
- includes an opening to fresh, clean and dry air, which is the equivalent of at least 2000mm².

Figure 1: Minimum Clearances, Services, and Mounting bolts layout .
 (All dimensions in mm).

**VIEW
A**

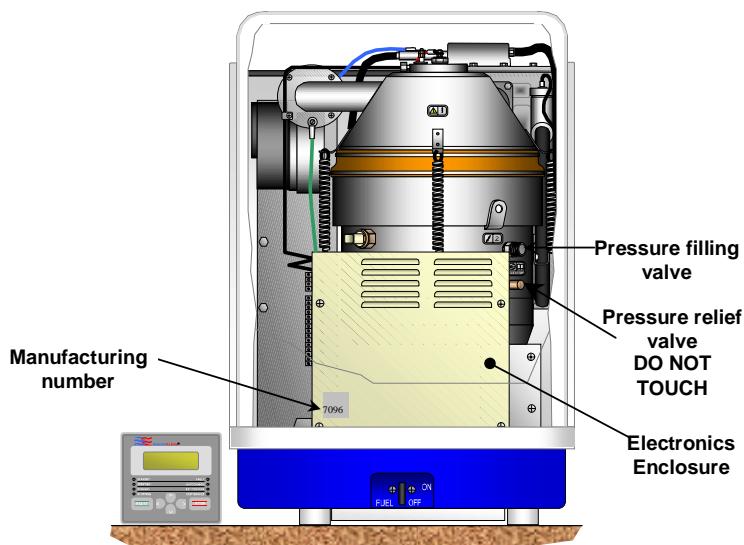


Plumbing connection sizes on WhisperGen	
No.	Size
1	¾ BSPP Female
2	¾ BSPP Male
3	1¼ BSPP Female
4	13mm OD

VIEW B

4. Pressurising the WhisperGen

- Warning:** The WhisperGen is a pressurised device. Contact your distributor if disassembly of the core engine is required.
- Warning:** The maximum pressure is limited by a pressure relief valve. This valve shall not be adjusted. A pressure relief valve is set at the factory, and any adjustment voids all warranties and can result in an unsafe and/or unreliable machine.
- Warning:** The filling pressures in this manual **only** apply to WhisperGens with manufacturing numbers which begin with a 3 or a 7. The four digit manufacturing number is stamped on the metal plate on the front of the electronics enclosure, (see figure below).
- Warning:** Pressurising of the engine must be done through a bottle mounted pressure regulator, (not supplied).
- Warning:** The WhisperGen must be depressurised before transporting by aircraft.



The WhisperGen is pressurised with nitrogen gas.

To pressurise the WhisperGen:

1. Attach the filler hose to the filling valve. The filler hose is available from authorised WhisperGen agents
2. Attach the filler hose to the Nitrogen bottle hose (not supplied), using the supplied ¼" BSP Male or Female fittings.
2. Open the hose tap.
3. Increase the regulator pressure to pressurise slowly to 22 – 24 bar cold (25°C). This will take 1 to 2 minutes.

Re-set the pressure to 28 ± 0.5 bar during commissioning, when the engine is hot, (70°C).

To de-pressurise the engine for transporting:

1. Attach the filler hose to the filling valve. Do not connect to the Nitrogen bottle.
2. Open the tap and slowly degas to 4 ± 0.5 bar. This will take 1 to 2 minutes.

5. Fitting the exhaust heat exchanger

The exhaust heat exchanger is de-coupled from the burner during shipping.

To fit the exhaust heat exchanger:

1. *Unbolt and remove the clamp holding the exhaust heat exchanger to the enclosure base.*
2. *Refit the bolt to the exhaust heat exchanger.*
3. *Fit the supplied gasket between the exhaust heat exchanger and the burner.*
4. *Firmly bolt the exhaust heat exchanger to the burner using the supplied nuts and washers.*

6. Plumbing the coolant circuits for the WhisperGen

Warning: A corrosion inhibitor shall be used in the primary coolant circuit because the engine is largely manufactured from aluminium alloy. See also section 8: Filling and bleeding the coolant circuits. The WhisperGen has **three** fluid circuits:

- the **primary** coolant circuit;
- the **secondary** coolant circuit; and
- the **flushing valve** fresh water circuit.

6.1 The primary coolant circuit

The primary coolant circuit recovers heat from the WhisperGen. The coolant flows directly through the engine. Heat is extracted from the primary coolant water by various optional heating devices, such as radiators and boilers, and either a water to water heat exchanger for marine systems or an external fan-radiator for land-based systems.

Primary coolant circuits for WhisperGens with a manufacturing number ending in 7 can be either **series** or **parallel**.

Primary coolant circuits for WhisperGens with a manufacturing number ending in 6 shall always be in **series** with the pump.

A **series** circuit (see *Figure 3: Primary coolant circuit - series*), is the preferred option because:

- it ensures that primary coolant is always flowing through all parts of the circuit; and
- it is self-bleeding of air.

A **parallel** circuit (see *Figure 4: Primary coolant circuit - parallel*) is not recommended because:

- it causes inconsistencies in the heating system; and
- it does not self-bleed. Air bleed valves are required at all high points in the parallel system.

6.2 The secondary coolant circuit

The secondary coolant circuit is used for rejecting excess heat. Heat is dumped into either:

- a marine seawater heat exchanger for marine systems; or
- a radiator, (liquid to air heat exchanger) with a fan for land based systems.

Marine versions of the WhisperGen are fitted with a titanium plate seawater heat exchanger.

Land based systems are not supplied with a primary radiator. A radiator which is appropriate for the application and environment should be selected.

Figure 2: Primary coolant circuit - series

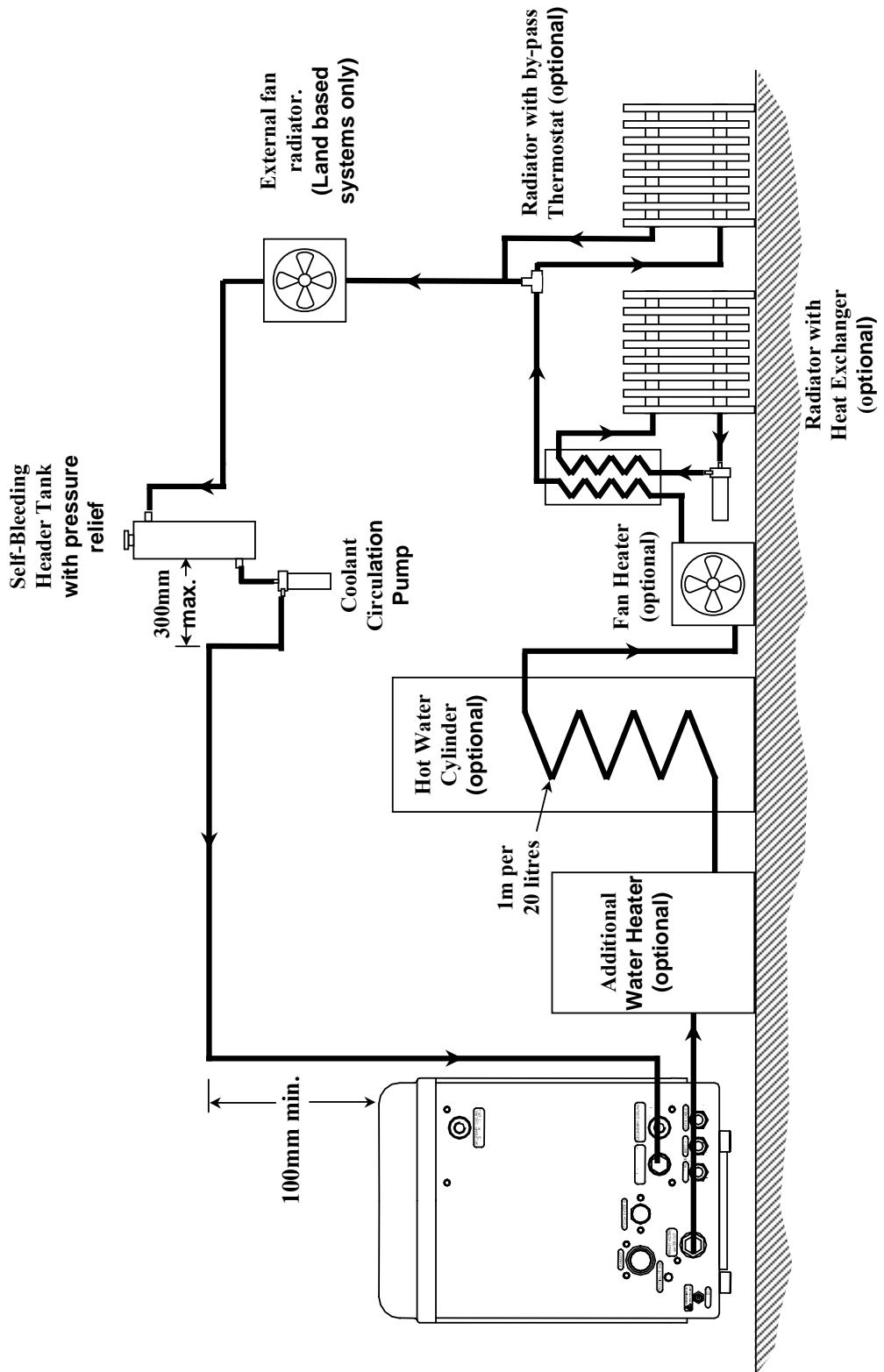
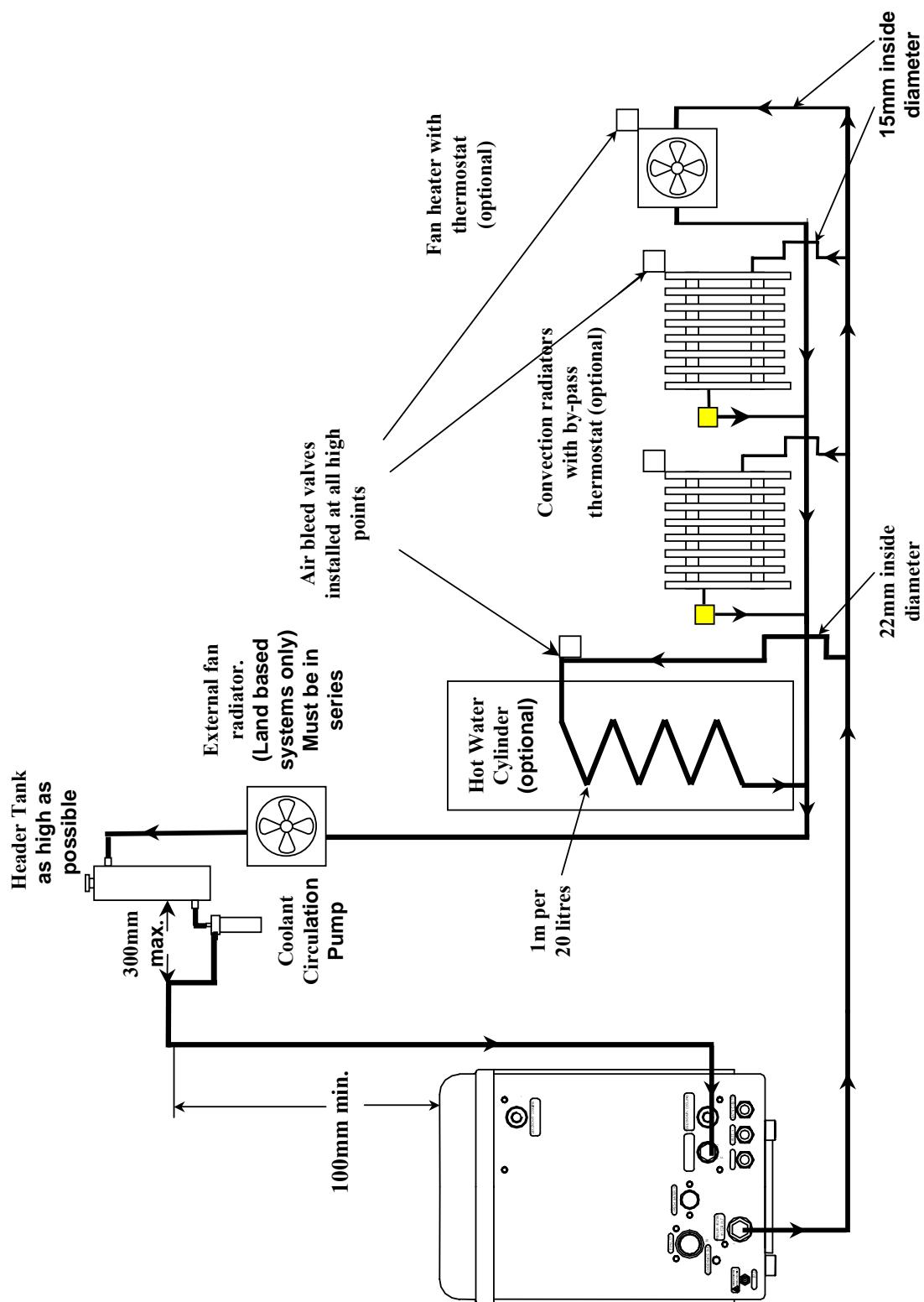


Figure 3: Primary coolant circuit – parallel



6.3 Plumbing the primary coolant circuit

See **Figure 2**: WhisperGen services layout, **Figure 3**: Primary coolant circuit – series; and **Figure 4**: Primary coolant circuit - parallel.

The WhisperGen primary inlet and outlet connections are ISO Rp ¾ BSP female threads. They are on the back of the WhisperGen enclosure, marked “PRIMARY HEATING IN” and ‘PRIMARY HEATING OUT’.

The primary circuit shall have a pressure relief system on top of the header tank, set at a maximum of 1 bar.

The tubing for the primary coolant circuit shall:

- have an inside diameter of between 19mm (¾") and 30mm (1¼");
- be rated for continuous operation at 100°C at 1 bar.
- be as short as possible, with a maximum length of 25 metres;
- have as few bends as possible with no sharp bends or kinks; and
- be clean and free of debris.

The primary coolant pump shall be mounted directly below the coolant tank.

For **series circuits**:

- a self-bleeding header tank shall be installed at the highest point in the circuit. The volume of the header tank shall be at least 5% of the total volume of coolant in the circuit. This will allow for thermal expansion of the coolant. Allow approximately 2 litres for the WhisperGen.
- the distance between the self-bleeding header tank and the primary coolant pump shall be a maximum of 300mm; and
- the minimum distance between the top of the WhisperGen and the outlet from the self-bleeding header tank is 100mm.

For **parallel circuits**:

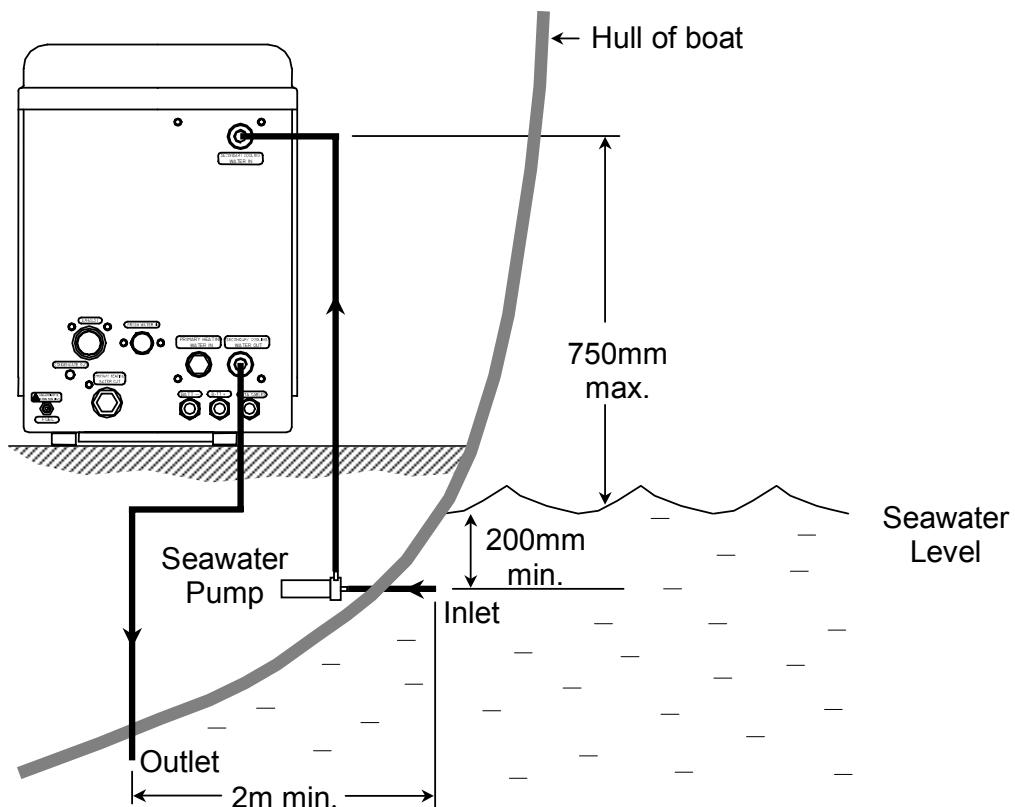
- air bleed valves shall be installed at all high points;
- the minimum distance between the top of the WhisperGen and the outlet from the header tank is 100mm; and
- the tubing which goes through the hot water cylinder shall have an inside diameter of 22mm. The rest of the plumbing shall use tubing with an inside diameter of 15mm. It is important that the flow restriction of the tubing which goes through the hot water cylinder is less than the other parallel heating devices.

6.4 Plumbing the secondary coolant circuit – marine systems

See **Figure 5**: Plumbing the secondary coolant circuit.

- Warning:** The inlet and outlet for the secondary coolant circuit shall not be connected to the inlet or outlet of another system.
- Warning:** The inlet and the seawater pump shall be under the water line by a minimum of 200mm at all times.
- Warning:** The inlet and outlet for the secondary coolant circuit shall be at least 2 metres apart.

Figure 4: Plumbing the secondary coolant circuit – marine systems



7. Setting up the battery and control system

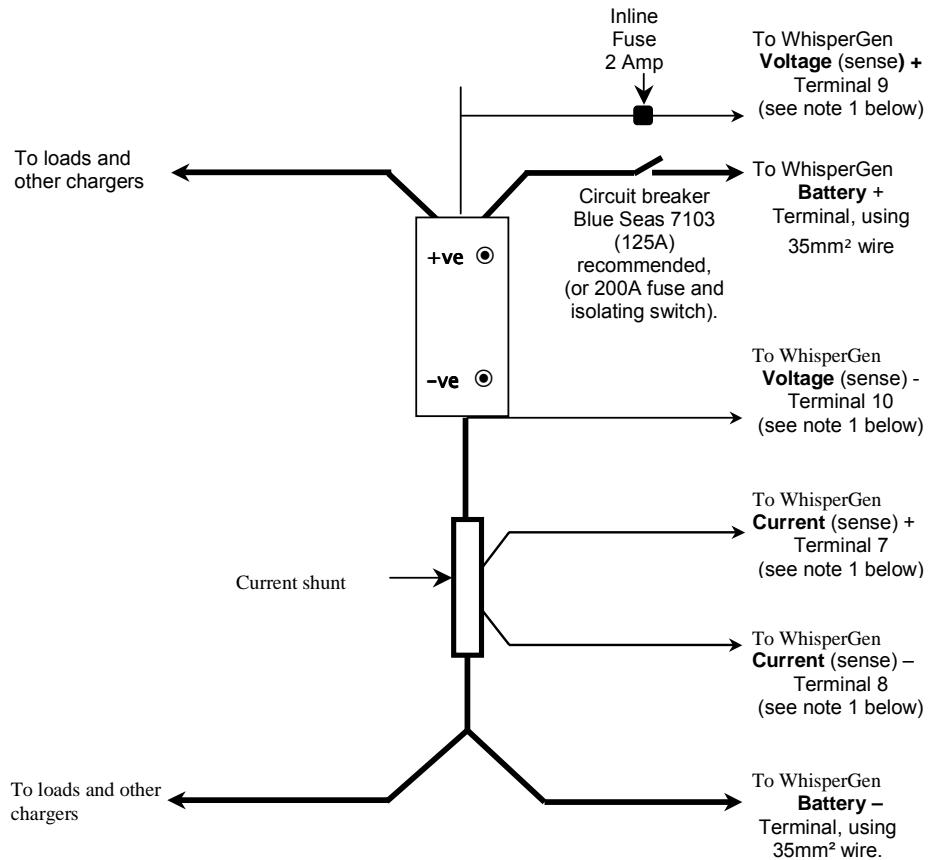
Warning: The WhisperGen electrical wiring shall comply with your local Electrical Code of Practice for extra low voltage installations.

Warning: For marine installations, **The Recreational Craft Directive 94/25/EC** shall apply to the installation. It has specific requirements for electrical connections and battery installation.

Warning: All positive connections from power sources and loads, except the battery, shall be made to the battery side of the WhisperGen circuit breaker.

Warning: All negative connections from power sources and loads, except the battery, shall be made to the non-battery side of the current shunt.

Figure 5: Setting up the battery



note 1: The conductor shall have a cross-sectional area of 1mm², or if it is in a multi-conductor sheath a cross-sectional area of .75mm².

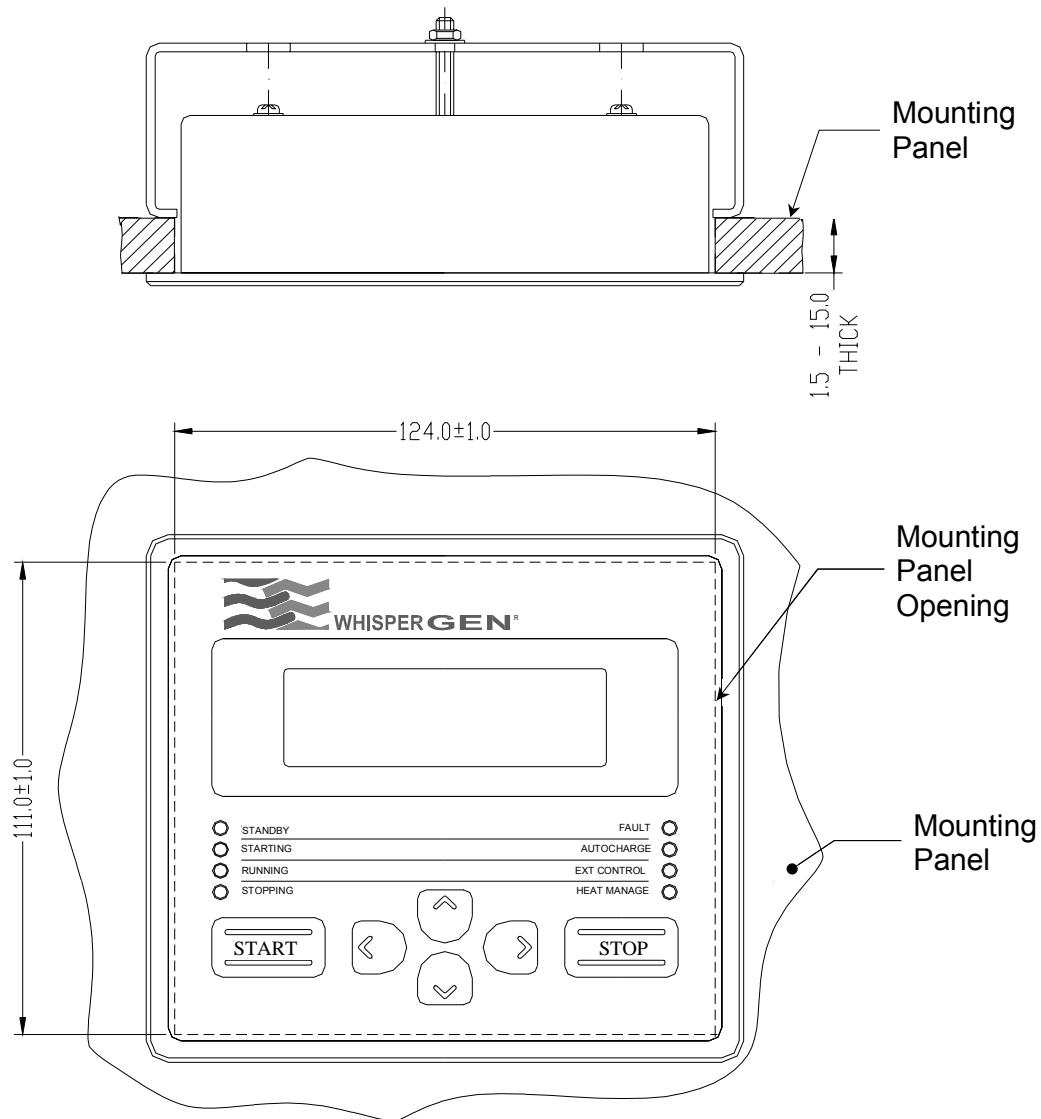
7.1 Mounting the control panel

See **Figure 7**: The control panel

To mount the control panel:

1. Select a site for the control panel which is dry and which allows free access for the communication cable.
2. Undo the clamp on the back of the control panel.
3. Cut a rectangular hole 127mm wide x 114mm high for mounting the control panel.
4. Use the clamp to secure the control panel in position.
5. Connect the communication cable to the back of the control panel, and run the wire back to the WhisperGen.

Figure 6: The control panel – cut out dimensions.



7.2 Connecting the battery

See **Appendix A** and **Appendix B** for recommended components.

See **Figure 8**: Wiring diagram.

To connect the battery:

1. Connect the positive lead. This is connected to the positive terminal of the battery bank via an isolating switch, and a battery fuse or circuit breaker.
2. Connect the negative lead from the battery negative terminal to the current shunt which is supplied with the WhisperGen.

This allows the WhisperGen to monitor all charge and discharge current. Do not make any other connections to the battery negative terminal or the battery side of the current shunt.

3. Connect the battery sense wiring loom from terminals 7 to 11:
 - connect the current shunt + sense wire to terminal 7;
 - connect the current shunt – sense wire to terminal 8;
 - connect the battery voltage + sense wire to terminal 9;
 - connect the battery voltage – sense wire to terminal 10; and
 - connect the battery temperature sense wire to terminal 11 and the battery negative terminal.

7.3 Control system connection points

7.3.1 Primary coolant pump

The power to the primary coolant pump terminals is supplied directly from the alternator of the WhisperGen. The pump will continue to run if the WhisperGen is running, and is disconnected from the batteries.

The WhisperGen turns on the water pump when it is started and turns it off when it is stopped and has cooled down.

The primary coolant pump shall be connected to terminals 18- and 19+. See **Figure 8**: Wiring diagram.

7.3.2 The Auxiliary DC Output

Warning: The primary coolant pump **shall not** be connected to terminal 14- and terminal 15+.

Warning: The combined current output from both the Auxiliary Power Output and the Ext PWM Output, shall not exceed 12A.

The WhisperGen has an auxiliary DC output, at battery voltage, to provide power to any other auxiliary equipment which is required to be switched by the WhisperGen.

Auxiliary power is available only when the WhisperGen is starting, running or stopping.

The Auxiliary DC output shall be connected to terminals 14- and terminal 15+. See **Figure 8**: Wiring diagram.

7.3.3 Secondary Coolant Pump

Warning: Do not use relays in this circuit.

A DC PWM output from the WhisperGen enables the WhisperGen to control the operating temperature of the system. It shall be connected to:

- the secondary coolant pump for marine systems; or
- the heat dump fan or land based systems.

The PWM output terminals are 12- and 13+ on the wiring block.

See **Figure 8**: Wiring diagram.

7.3.4 External Digital In

Warning: Do not apply voltage across these terminals.

These inputs allow the WhisperGen to be turned on and off by an external set of contacts. The contacts can be a switch, thermostat, timer or some other device which starts and stops the WhisperGen. The contacts shall be physical or 'dry contacts'.

The EXT Digital In input terminals are 5+ and 6- of the wiring block. See **Figure 8**: Wiring diagram.

7.3.5 External Digital Out

The maximum output current is 100mA.

The External Digital Out is a low current, 5V digital output which allows the WhisperGen to control the temperature of the coolant by switching an optional additional water heater on and off. The output is logic only and cannot drive a relay, but is suitable for digital input to another device.

The EXT Digital Out output terminals are 3+ and 4- of the wiring block. See **Figure 8**: Wiring diagram.

7.3.6 External Temperature

These terminals are not used. They are 1 and 2 of the wiring block.

7.3.7 Fuel Pump

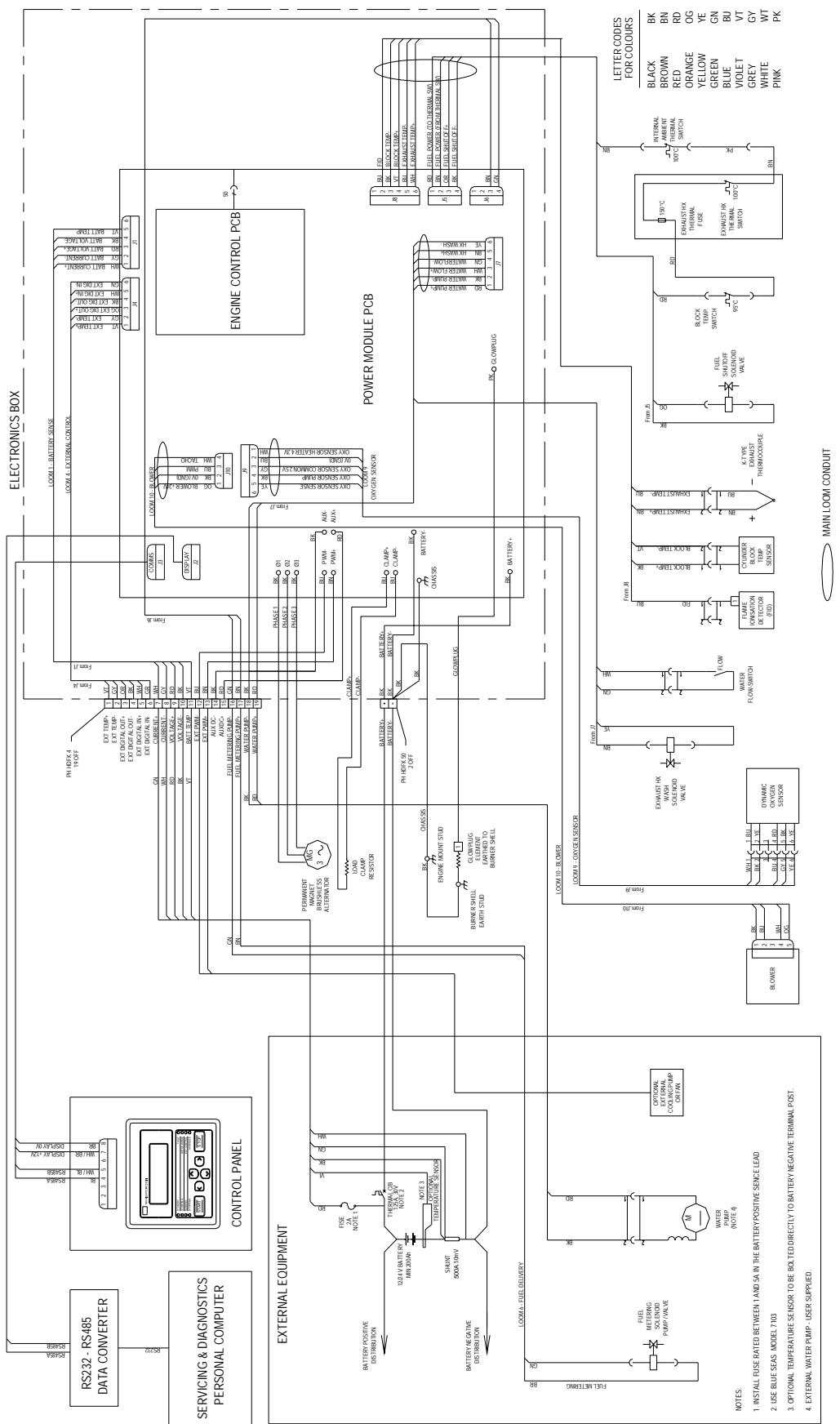
WARNING: Only use the fuel pump supplied with the WhisperGen.

The fuel pump is a solenoid-operated piston pump. The speed of operation of the fuel pump is controlled by the WhisperGen microprocessor. The positive and negative poles of the fuel pump can be swapped.

The arrow on the fuel pump indicates the direction of the fuel flow.

The fuel pump shall be wired to terminals 16 and 17 of the wiring block. See **Figure 8**: Wiring diagram.

Figure 7: Wiring Diagram



8. Filling and bleeding the coolant circuits

Warning: A corrosion inhibitor shall be used in the primary cooling circuit because the engine is largely manufactured from aluminium alloy. A good quality corrosion inhibitor shall be used.

Warning: If ethylene glycol, (automotive anti-freeze) is used as the corrosion inhibitor, a minimum of 35% undiluted glycol to 65% fresh water solution shall be used for the coolant. A higher concentration of glycol may be needed if the coolant system is subject to very low temperatures.

Warning: It is essential that the primary coolant is clean and free from debris. Foreign particles can obstruct internal coolant passages and damage the WhisperGen. Contaminated circuits shall be fitted with sludge traps upstream of the WhisperGen.

Warning: Anything connected to the AUX DC terminals will be powered up when the primary and/or secondary coolant circuits are bled.

A drain tap allows coolant to be drained from the WhisperGen engine. The drain tap is on the lower left-hand side of the engine housing, and is accessed through the front cut on the mounting frame. This valve must be closed at all times.

To bleed the primary coolant circuit:

1. *Fill the primary coolant circuit header tank with coolant.*
2. *With the header tank full, slowly unscrew:*
 - *the small bleed valve which is fitted to the top left-hand side of the WhisperGen exhaust heat exchanger; and*
 - *any other bleed valves fitted to the circuit.*
3. *Leave the bleed valve(s) open until the coolant begins to dribble out, and then close immediately.*
4. *Close the WhisperGen circuit breaker and ensure that text is displayed on the control panel.*

Warning: Before continuing with the installation the Enable Starts option in the Installation Menu should be set to 0 to prevent unintentional starts of the WhisperGen. For further information see the User's Manual, section 3.

5. *Press < on the control panel until the default display is displayed.*
6. *Press > to display the first item on the **Main Menu**, the **User Menu**.*
7. *Press v to scroll down to the **Installation Menu**.*
8. *Press > to display the first item on the **Installation Menu**.*
9. *Press v to scroll down to **Coolant Bleed**.*
10. *Press > to begin editing the **Coolant Bleed** setting.*
11. *Press ^ to select **On**. The coolant pump will be turned on to bleed the coolant circuit.*
12. *Continue to fill up the header tank until it will not accept any more coolant. Make sure the header tank does not run dry.*

13. Make sure that the coolant is flowing at a minimum flow rate of 6 litres per minute.
14. Check the primary coolant circuit for leaks.
15. Open the bleed valves as necessary to remove air from the circuit.

To bleed the secondary coolant circuit:

1. Access the **Main Menu** on the control panel.
2. Press **v** to scroll down to the **Installation Menu**.
3. Press **>** to display the first item on the **Installation Menu**.
4. Select **Coolant Bleed 2**.
5. Press **>** to begin editing the coolant bleed setting.
6. Press **^** to turn the **Coolant Bleed 2** function to **On**.
7. Check that the pump is priming and that seawater is flowing from the outlet.
8. Check that the secondary coolant circuit has a minimum flow rate of 4 litres per minute.
9. Check the secondary coolant circuit for leaks.

The secondary coolant pump will run for 1 hour after being turned on before automatically turning off. It can be turned off, if necessary, at any time, by turning the **Coolant Bleed 2** function to **Off**.

9. Setting up combined heating and battery charging

9.1 Setting up hot water heating

Warning: If a thermostat is used to start the WhisperGen, it shall be set 5°C below the coolant temperature set point, (refer to the control panel). If the thermostat is set higher than the coolant temperature set point, the WhisperGen will not be able to heat the water in the hot water cylinder/boiler to a high enough temperature to turn the WhisperGen off.

Warning: The hot water cylinder/boiler shall have a heating coil length of 1 metre per 20 litres water capacity, up to a recommended maximum of 10 metres.

A hot water cylinder/boiler with a minimum 40 litres capacity is recommended.

To set up hot water heating:

1. *Connect a thermostat to the hot water cylinder, and the **External Digital In** contacts on the electronics enclosure.*
2. *On the control panel, turn **External Control** to **On**, and select **Mode 2**. (**Mode 1** can be used if required). (Refer to the user manual for more information).*
3. *Set the thermostat at least 5°C below the **Temp Setpoint**. This is to ensure that the thermostat will open, and turn the WhisperGen off.*

9.2 Setting up space heaters

The heat output (kW) rating of most commercially available space heaters is rated with a room temperature of 20°C and a surface temperature, (coolant temperature), of 80°C. The maximum coolant temperature setting for the WhisperGen is 70°C. To ensure that the full heat capacity from the WhisperGen can be used, the size (heat output), of the heaters shall be 7.2kW. This is equivalent to 6kW at 80°C.

Fan heating:

To connect a fan heater:

1. *Plumb the primary coolant through the radiator core.*
2. *Connect the electric fan to a separate room thermostat to turn the fan on and off.*

See **Figure 3**: Primary coolant circuit – series.

Convection radiator heating:

For convection radiator heaters, which are **fitted with a bypass thermostat valve**, plumb as for fan heating.

For convection radiator heaters, which are **not fitted with bypass thermostat valves**, install an additional heat exchanger and pump, and ensure that the pump is switched by the room thermostat. See **Figure 3**: Primary coolant circuit – series

Additional heating device:

An additional heating device shall be fitted if the heat supplied by the WhisperGen is not enough to meet the required heat demand. The WhisperGen will control the function of the additional heater and only turn it on as required.

10. Setting up the fuel system

Warning: The WhisperGen burner is fuel specific and can operate only on the fuel it has been configured for. The evaporator at the top of the burner is marked 'D' for diesel and 'K' for kerosene.

Warning: For the **diesel burner** use only good quality automotive diesel (BS2869: 1988 burner fuel class D) with the WhisperGen. Do not use other fuel types such as heating oil, petrol, aviation fuel, and LPG.

For the **kerosene burner** use only good quality automotive kerosene (BS2869: 1988 burner fuel class C2).

Warning: An approved fuel line with an inside diameter of between 2.5mm and 3.5mm shall be used. A line with a larger inside diameter may cause air/vapour bubbles to form in the fuel line. This may make it difficult to start the burner and may extinguish the flame during operation. The fuel line shall be a maximum of 8m in length. Header or day tanks shall be used for longer runs.

Warning: The distance from the fuel pump and filter to the fuel tank shall be a maximum of 200mm.

Warning: For marine installations, the fuel system installation where applicable, shall comply with the **Recreational Craft Directive 94/25/EC**, issued by the Council of the European Community.

Warning: Bleeding the fuel system will cause water pumps and fans to start. Ensure pumps and coolant circuits are installed and bled before bleeding the fuel system.

If the fuel line is connected to a fuel tank used by other equipment, draw the fuel supply from a separate outlet.

An ISO Rp $\frac{1}{8}$ female fitting is provided on the back of the WhisperGen enclosure for the fuel inlet.

Mount the supplied fuel pump:

- upright at the fuel tank outlet;
- level to, or below the bottom of the fuel tank; and
- on a soft rubber pad to prevent noise transmission.

An inline filter shall be fitted between the fuel tank and the fuel pump.

To prevent air/vapour bubbles collecting, all changes in height in the fuel line shall be free of dips or loops.

The vertical range of the fuel level in the tank relative to the base of the WhisperGen is +2m, -1.25m, see **Figure 9: Fuel pump and fuel line installation**.

It is recommended that a short length of approved flexible fuel line be installed on each side of the pump to stop the ticking noise being transmitted into the metal fuel line.

10.1 Bleeding the fuel system

At least twice the volume of fuel in the entire fuel line connecting the fuel tank to the burner evaporator, shall be bled. For example, if the fuel line measures 3mm in inner-diameter and 5 metres in length, then a minimum of 70ml of fuel shall be bled.

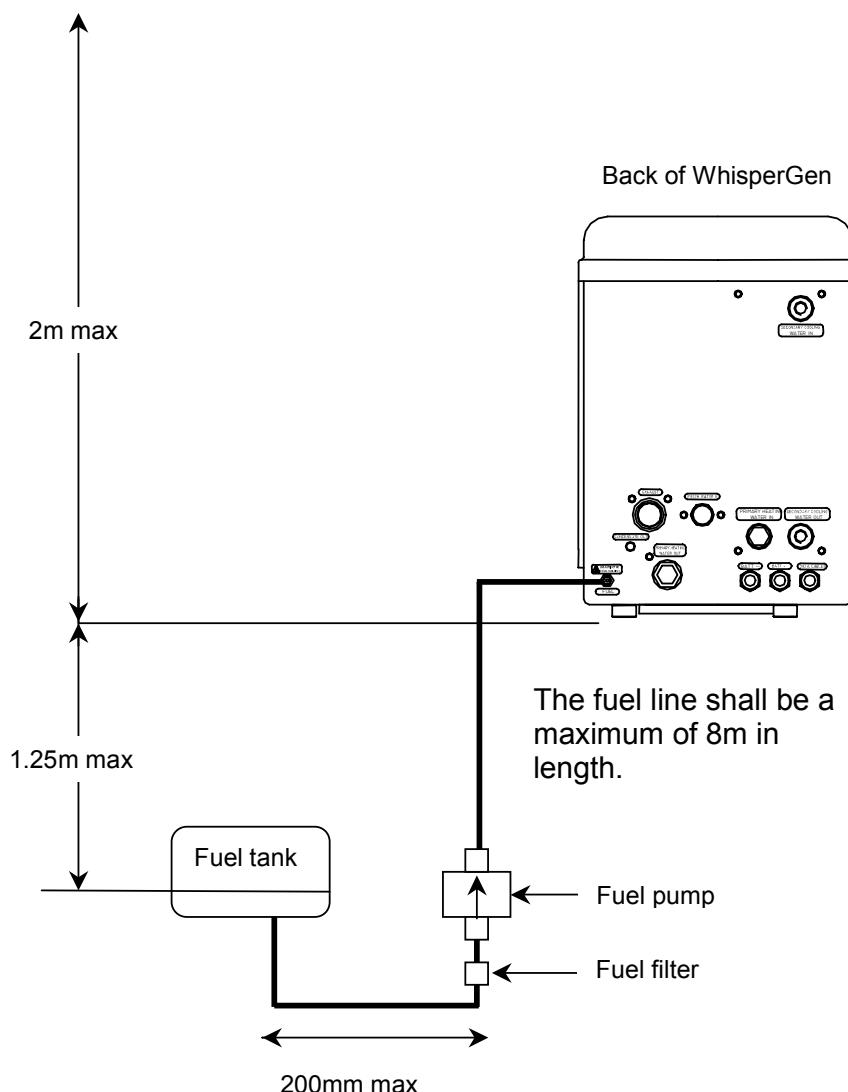
The default Fuel Bleed function will bleed the system in pulses for 60 minutes. The fuel pump can be stopped at any time by pressing **v**. Approximately 1 litre of fuel will be collected in 60 minutes. The fuel system shall be bled for a minimum of 30 minutes.

To bleed the fuel system:

1. *Make sure that all fuel fittings are tight and not leaking. Pressure test the fuel line from the fuel tank to the WhisperGen to 1 bar, and check for leaks.*
2. *Undo the fuel line from the evaporator on top of the burner. Direct any diesel which comes out of the fuel line into a container.*
3. *Turn on the fuel tap:*
 - *at the fuel tank; and*
 - *at the bottom front of the WhisperGen.*
4. *On the control panel, access the **Installation Menu**.*
5. *Press **>** to display **Fuel Bleed**.*
6. *Press **>** to begin editing the **Fuel Bleed** setting.*
7. *Press **▲** to select **ON**.*
8. *Reconnect the fuel line to the evaporator. Ensure that the fitting is secured tightly, and that there is no leakage.*
9. *Check that the fuel flow rate is $10\text{cc} \pm 1.5\text{cc}$ per minute.*

Note: When the fuel system is being bled, the primary coolant pump and any components connected to the Aux DC terminals, will be turned on.

Figure 8: Fuel pump and fuel line installation



11. Setting up the exhaust system

Warning: The exhaust outlet shall not be connected to the exhaust system of another engine or heating device.

Warning: The WhisperGen exhaust shall be freely vented to the outside at all times.

Warning: Condensate forms down the entire length of the exhaust pipe under all operating conditions. Condensate drains shall be run from all points in the exhaust where condensate is likely to be trapped. The condensate shall be drained into the waste water tank, or a suitable collection point for combustion condensate. **Condensate drains shall contain an air trap** to prevent exhaust gases leaking into the boat, or living spaces. The minimum air trap tube size is 10mm for vented drains/tanks and 15mm for non-vented tanks.

Warning: For marine installations the exhaust outlet shall not be submerged at any time. See **Figure 10:** Exhaust piping for marine use.

Warning: The exhaust pipe shall always have a slope of at least 10° relative to the horizon. Momentary changes of slope, to less than 10°relative to the horizon (caused by a boat going over a wave or swell), are acceptable. See **Figure 10:** Exhaust piping for marine use.

Warning: The exhaust back-pressure, measured at the WhisperGen exhaust port shall not exceed 7mm H₂O with Exhaust Temp greater than 400°C when the Air % is at approximately 100%. This is about 20mm H₂O with the Exhaust Temp less than 30°C. Higher back pressures will significantly reduce the power output of the WhisperGen.

Warning: The condensate drain shall be free from obstructions at all times.

The service connection on the back of the WhisperGen has an ISO Rp 1½ female pipe thread.

The condensate drain uses 13mm inside diameter tubing. The drain, or pipe, shall not be higher than the service connection on the WhisperGen.

The exhaust pipe shall be:

- short with few bends; and
- fitted with a weather protection cowling at the exhaust outlet.

Extra exhaust pipe slope may need to be installed to compensate for boat heel. This is especially important for a yacht which has an exhaust pipe running from port to starboard.

To set up the exhaust system:

1. Attach the exhaust pipe to the exhaust exit at the back of the WhisperGen.
2. Make sure that the exhaust pipe will always have a slope of 10° relative to the horizon.
3. When the WhisperGen is not running, use the **Bleed Air** function on the control panel (or push the start and then the stop button), to make the burner fan operate at 100%.
4. Measure the exhaust back-pressure at the condensate outlet on the back of the WhisperGen. The back pressure should not exceed 7mm H₂O with Exhaust Temp greater than 400°C when the Air % is approximately 100%.
This is about 20mm H₂O with the Exhaust Temp less than 30°C.

The following table details exhaust pipe sizes

Pipe inside diameter (mm)	Maximum length of straight walled exhaust pipe (m)	Maximum length of corrugated walled exhaust pipe (m)
32	4	2.5
40	6	4
45	8	6
50	10	8

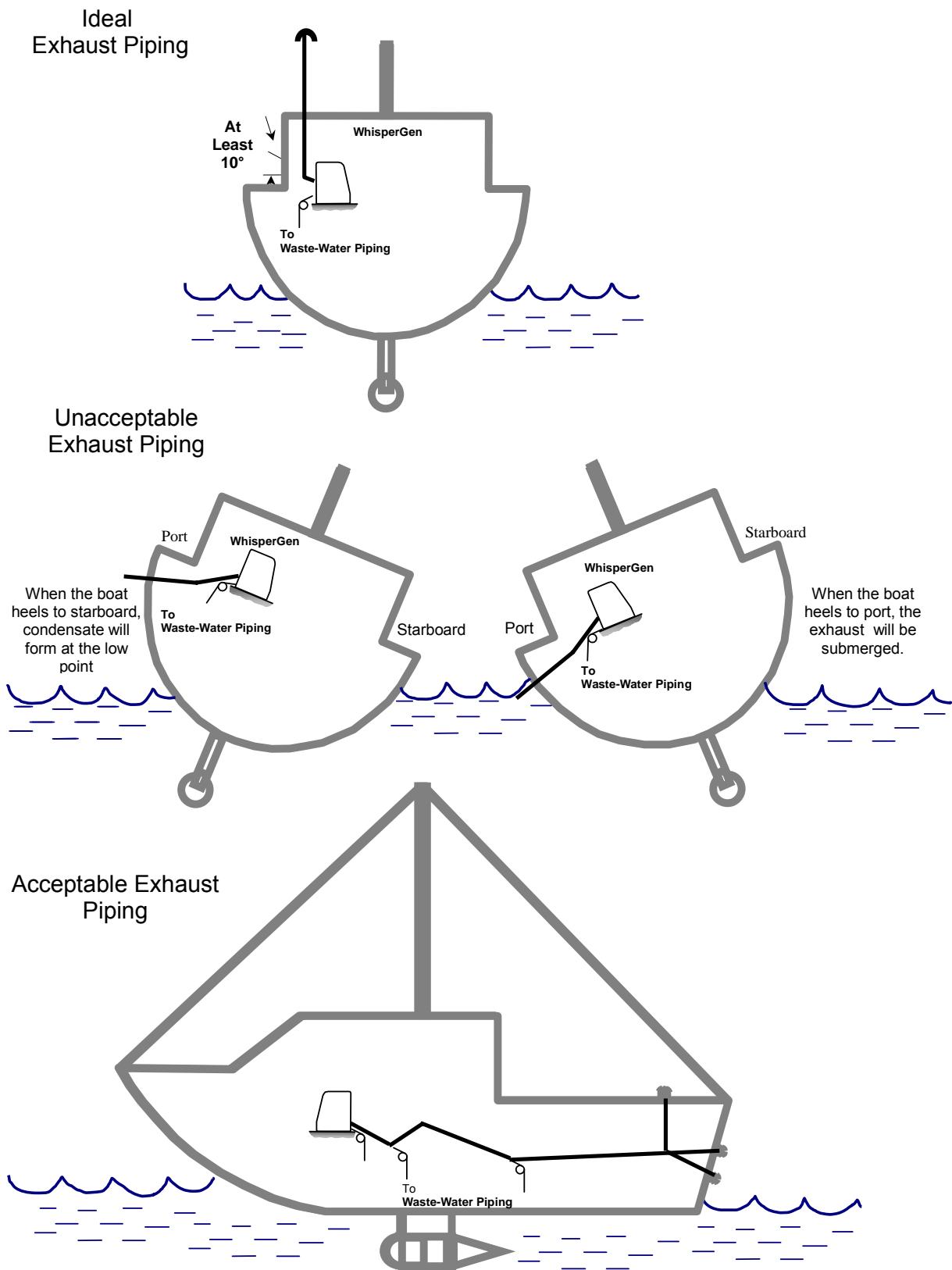
11.1 Fresh water flushing of the exhaust heat exchanger

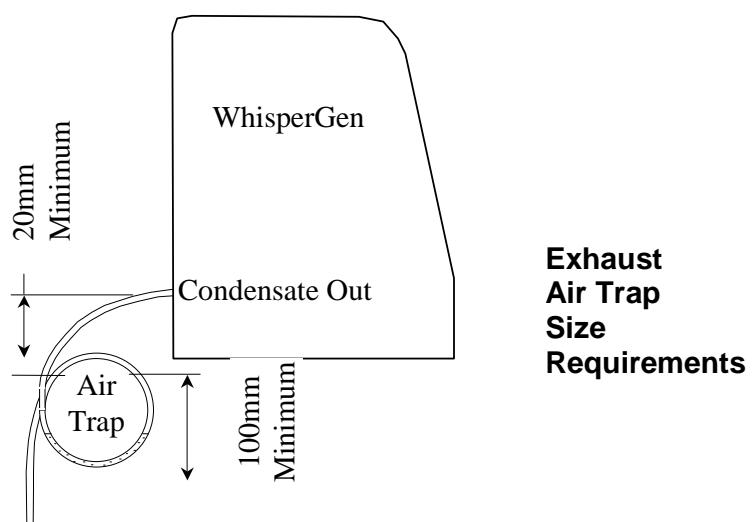
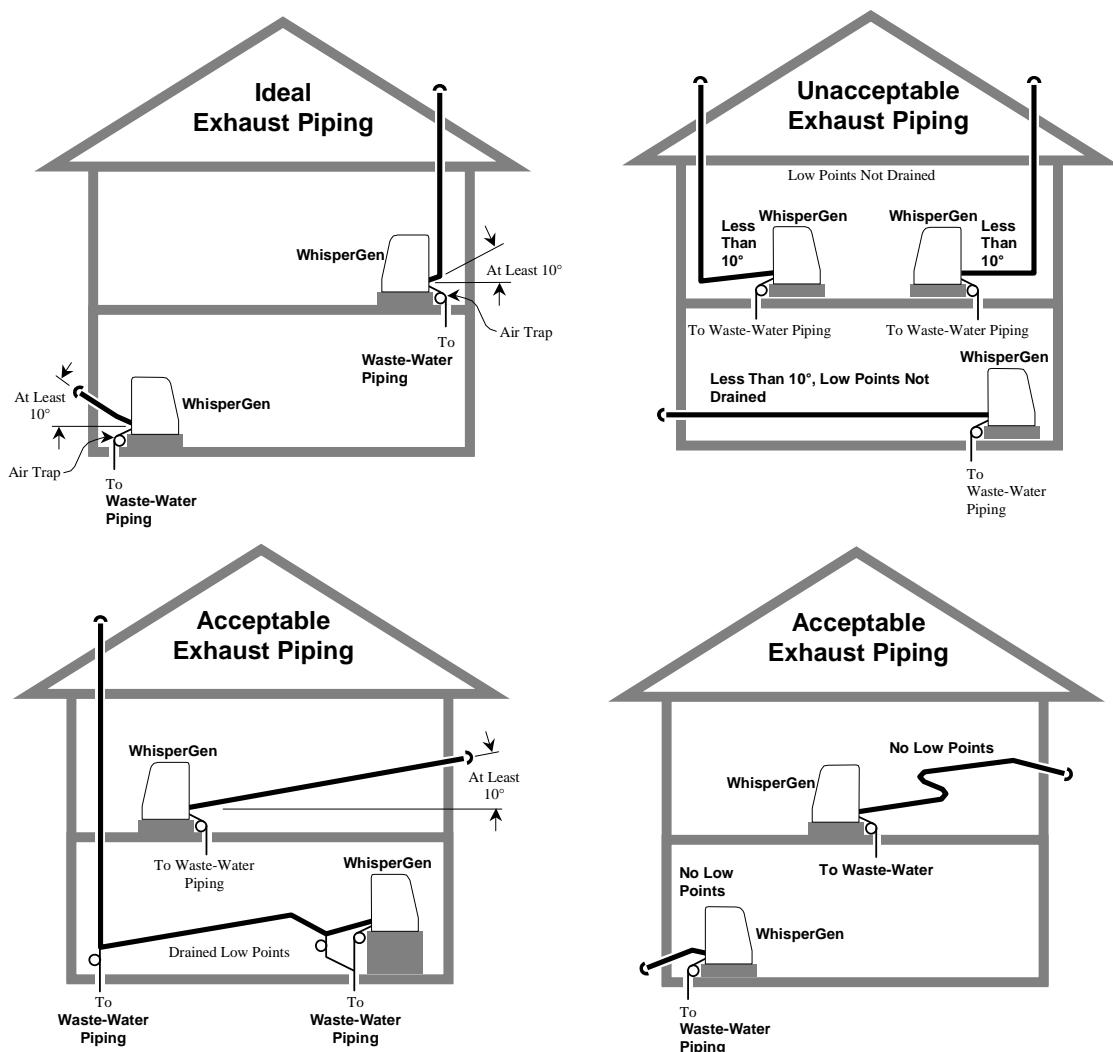
The exhaust heat exchanger is flushed with fresh water each time it is started to prevent water soluble deposit build-up from the fuel. This is done with a spray nozzle at the top of the exhaust heat exchanger. The flushing uses about 0.25 litre each time. It drains out of the "Condensate Out" tube at the back of the WhisperGen.

The fresh water supply is connected to the WhisperGen Fresh Water In connection on the back of the WhisperGen. This is a ¾" BSPP Male connection. The fresh water shall be at a pressure of a minimum of 1.5 bar and a maximum of 6 bar. Fresh water is normally plumbed from the domestic pressurised fresh water supply.

Water with high concentrations of Calcium or Magnesium, (hard water), will cause the nozzle to block. The nozzle shall be cleared regularly to ensure reliable operation.

Figure 9: Exhaust piping for marine and land based systems





COMMISSIONING CHECKLIST

To validate the warranty for the WhisperGen the commissioner shall:

- complete the commissioning checklist in full.
For checkpoints which are not applicable, enter “n/a”
- send a copy of the commissioning checklist to the authorised WhisperGen supplier.

WhisperGen PPS16 Commissioning checklist.

WhisperGen Engine Serial number	
Date of commissioning	
Commissioner:	Full name: Address: Phone: Fax: E-Mail:
Owner:	Name: Address: Phone: Fax: E-Mail:
Location of WhisperGen or home shipyard of boat:	Name: Address: Phone: Fax: E-Mail:
Details of boat:	Type and size of vessel: Location of WhisperGen in vessel:

Page	Task	Details	Complete (✓)
	User's manual read and understood		
	Installation checklist complete		
30	WhisperGen checked, complete and undamaged.		
4	The WhisperGen is pressurised with nitrogen gas.		
31	Microprocessor monitoring understood.		
31	Computer connected to WhisperGen for commissioning.		
32	Battery Volts are 0.6 ± 0.1 greater than the Bus Voltage when WhisperGen is in Standby mode.		
32	Battery Amps reads negative when power is being removed from battery.		
32	The difference between the Battery Volts and the Bus Voltage is not more than 0.20V with the glowplug on.		
32	First StartFuel value.		
32	Additional heater is functioning.		
32	Time for flame to register after fuel is turned on, (seconds).		
32	FID reading at end of stabilising period.		
33	O2 Value at the end of the stabilising period.		
33	Maximum O2 Ave Error reading during heat up.		
33	Gross Watts 5 seconds after cranking.		
33	Gross Watts 5 minutes after cranking.		
33	Coolant temperature after 25 minutes running.		
33	Ext PWM		
33	Ambient air temperature .		
33	Ambient secondary coolant inlet temperature .		
	Heat manage functions correctly.		
	Ext. Control functions correctly.		
	Auto-charge functions correctly.		
	Heat dump test second reading		



Fill out the values below when commissioning is complete.

Item	Details	Complete (✓)
Full power operating parameters		
Complete this section when:		
<ul style="list-style-type: none"> • Runtime (Min) is greater than 45; • Bulk charge is displayed on the control panel; • Coolant Temp is between 67 and 72; and • Battery Volts are between 13.7 and 14.3 for 12V systems and 27.4 and 28.6 for 24V systems. 		
Battery Volts		
Battery Amps		
Battery Amp-hrs		
Battery Watts		
Gross Watts		
Runtime (Min)		
Hour Meter		
# of Starts		
Alt Current		
Air %		
Bus Voltage		
Coolant Temp		
Clamp Current		
Clamp Voltage		
Exhaust Temp		
FID Current uA		
Fuel Cut Off		
Fuel Metering		
Fuel Frequency		
O2 Value		
O2 Ave Error		
Software Ver		
Nitrogen gas pressure reading		
NumFaults		

Battery Settings In Hidden Service Menu		
Battery Capacity set to		
Max Battery Discharge set to		
Tail Current set to		
Absorb voltage set to		
Float Voltage set to		
Time >14V or Time >28V set to		
SelfDisch/Mth set to		

User Adjustable Settings	Details	Complete (✓)
LCD display contrast setting OK		
LCD display back light setting OK		
Heat manage set to		
Temp setpoint set to		
Auto-charge set to		
Ext. Control set to		
Ext. Control Mode set to		
Max Run Hhours set to		
Enable Starts set to		
Second StartFuel1 value		
Name and signature of commissioner.		

12. The control panel user settings

Refer to the **User's Manual** for instructions for setting:

- LCD Display Contrast
- LCD Back Lighting
- Heat Manage
- Temp Setpoint
- Auto-charge
- Ext. Control
- Ext Control Mode
- Max Run Hours

13. Battery settings

Warning: the recommendations of the battery manufacturer should be followed.

Battery settings are made in the hidden **Service Menu**.

To access the hidden menu:

1. Select the **Main Menu** on the control panel.
2. Press **v** until the control panel displays:

"End of menus Press UP or <"

3. Press:
 >v
 >vv
 >vvv>

"Authorised service personnel only" is displayed on the control panel.

4. Use the **v** to scroll through and set the variables.

The battery settings are:

- **Battery Capacity**

This is the battery capacity in ampere hours, at the 20 hour rate of the battery.

- **Max Battery Discharge**

This is the amount the battery can be discharged as a decimal percentage of the **Battery Capacity** before the **Auto-Charge** function will automatically start the WhisperGen, charge the battery, and then stop the WhisperGen. The default setting of 0.35 (that is 35%), is usually adequate for most systems.

- **Tail Current**

When the battery current reaches the **Tail Current** during charging, the battery is defined by the WhisperGen as charged.

The default setting for **Tail current** is 0.07 (7%), of the Ampere hour rating of the battery and this is adequate for most systems. For example: for a 300 Ah battery, when the battery is at absorption voltage and the charging current drops to 21 amps, the battery is defined as charged, ($300 \times 0.07 = 21$).

- **Absorb Voltage**

Warning: The Absorb Voltage is specific to the battery. Battery manufacturer's recommendations shall be followed.

The **Absorb Voltage** is the maximum voltage for the battery during battery charging. The **Absorb Voltage** is specific to the battery.

The default setting is 14.4V for 12V systems and 28.8V for 24V systems. This is usually adequate for lead acid or gel batteries.

- **Float Voltage**

Warning: The Float Voltage is specific to the battery. Battery manufacturer's recommendations shall be followed.

This is the voltage which the battery is held at if the WhisperGen continues running after the battery has been defined by the WhisperGen as fully charged.

The default setting is 13.8V for 12V systems and 27.6V for 24V systems.

- **Time >14V**

This is the maximum time, in hours, that the battery bank can be held above 14V for 12V systems and 28V for 24V systems, before the battery is considered to be fully charged.

It is a back-up to the **Tail Current** to prevent the battery being held at high voltage if the load should exactly match the generation capability of the WhisperGen, or an old battery is being used.

The default setting is 4 hours. It shall be greater for larger batteries and less for smaller batteries.

- **SelfDisch/Mth**

Warning: The SelfDisch/Mth is specific to the battery and the recommendations of the battery manufacturer shall be followed.

This is the self-discharge rate of the battery bank expressed as a decimal % per month when no external load is applied. For example, 0.1 is equal to 10% self discharge per month. The default setting is 0.05. This is usually adequate for gel batteries. For lead acid batteries, the value should be increased to 0.10.

14. WhisperGen check

To check the WhisperGen before commissioning:

1. Remove the enclosure cover and ensure that:

- spare parts, tools and the **User's Manual** are present;
- there is no damage to the WhisperGen engine;
- the burner is correctly positioned; and
- the red silicon rubber burner seal, and springs are in place.

If the WhisperGen is damaged, or parts are missing, contact the WhisperGen distributor.

2. Ensure that the WhisperGen has been pressurised with nitrogen gas.

See page 4 **Pressurising the WhisperGen**, in the Installation section of this manual.

3. Ensure that the exhaust heat exchanger has been bolted to the burner.

See page 5 in the Installation section of this manual.

15. Monitoring the WhisperGen using the Control Panel.

Warning: If Auto restart is set to >0, the WhisperGen may attempt to restart automatically After a fault.

See the WhisperGen User's Manual for control panel operation.

The WhisperGen control system monitors the starting, and running phase of the WhisperGen by checking the values given by the sensors.

If the microprocessor finds that sensor values are outside a specific range, (set in the WhisperGen control program), then the WhisperGen produces a warning or fault, and in some cases it is shut down.

To restart the WhisperGen after it has automatically shut down:

- If the cause of the shutdown is known, fix the fault, and clear the fault from the screen. Fault codes and suggested fixes are given in the WhisperGen User's Manual.
- try to restart the WhisperGen. The WhisperGen must complete its cooldown routine before a restart.

16. Monitoring the WhisperGen using a computer.

This option provides monitoring of the WhisperGen by a personal computer and “Micromon MO” software which shall be used to aid commissioning of the WhisperGen.

See **Figure 11**: Micromon MO screen.

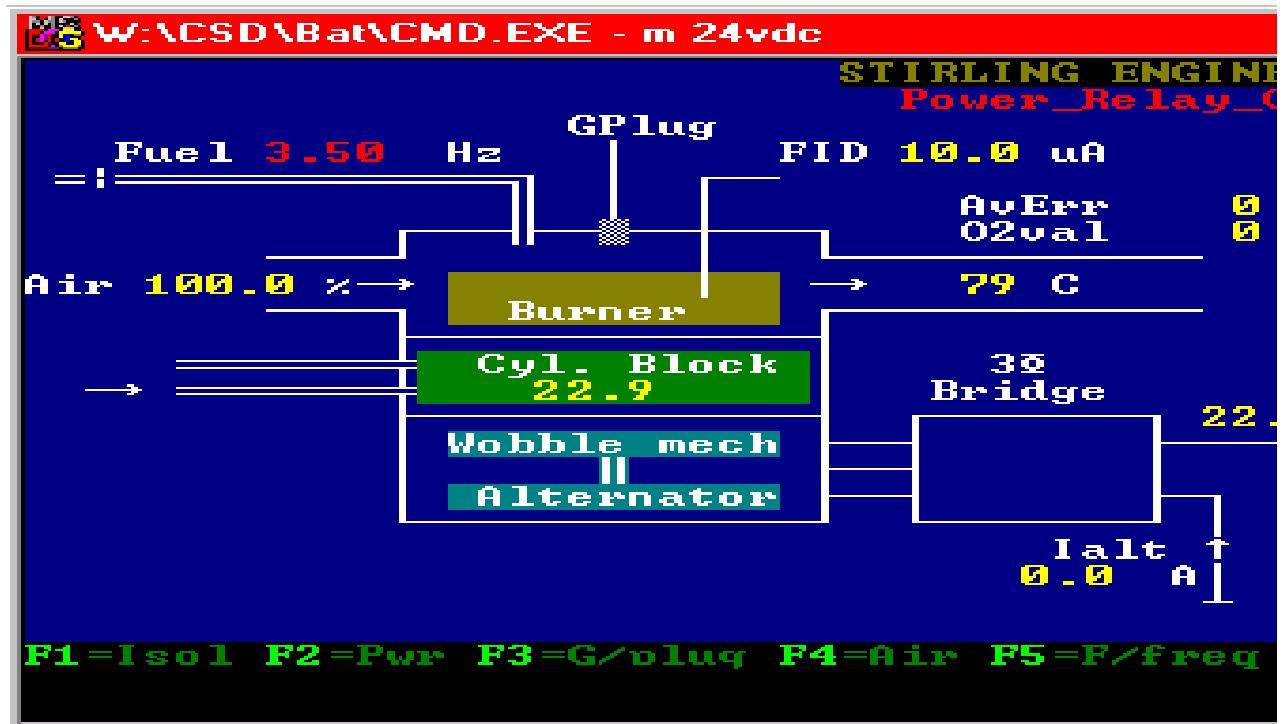
The Micromon MO software allows:

- all variables in the **Extra Info Menu** to be viewed on screen at the same time, instead of one at a time on the control panel.
- the recording of a log file detailing the readings of the WhisperGen sensors. This is useful for fault solving.

Micromon MO software will run on a personal computer which is a minimum of an IBM 386 or compatible.

To install the Micromon MO software follow the instructions in the “DoReadMe.txt” file on the supplied disk. Instructions for connecting the computer to the WhisperGen are in this file.

Figure 10: Micromon MO screen



17. Running the WhisperGen for the first time

To run the WhisperGen for the first time:

1. Complete sections 1 to 15 of this manual.
2. Connect the monitoring computer to the WhisperGen and start Micromon MO.
3. Put the WhisperGen into **Standby** mode by pressing the start button for five seconds.
4. Check that the **Battery Volts** are 0.6 ± 0.2 greater than the Bus Voltage. If not, check that the battery voltage sense wires are connected.
5. Ensure that the WhisperGen is the only charging device connected to the battery and that there is no current going into, or out of the battery.
6. Push the WhisperGen start button for one second.
7. On the Micromon MO screen check that **Battery Amps** shows a negative reading. If the **Battery Amps** reading is positive, reverse the battery current shunt sense wires at either the current shunt, or at terminals 7 and 8.
8. The WhisperGen will power up and turn on the glow plug. This takes about 15 seconds. Check that **Battery Volts** is a maximum of 0.20 volts greater than the **Bus voltage**.

With the glow plug on, the load on a 12 volt battery should be approximately 35 amps. The load on a 24V battery should be approximately 18 amps.
9. Press the stop button for one second. The WhisperGen will shut down.
10. Select the **Installation Menu** on the control panel and select the following settings:
 - **Enable Starts** shall be set to **2**;
 - **Heat Manage** shall be set to **Off**.
 - **Auto-charge** shall be set to **Off**.
 - **Ext. Control** shall be set to **Off**.
 - **Max Run Hours** shall be set to **25**.
11. Write down the **StartFuel1** value. This is about variable 73 on the Micromon MO screen.
12. Press the start button
The additional heater water pump should run every time the WhisperGen is powered up, even if it is not producing heat.
13. If an additional water heater is fitted, turned on at the main switch, controlled by the WhisperGen, and the Coolant Temp is less than the Temp Setpoint, check that the additional water heater coolant pump is working correctly.
14. Record the time it takes between the fuel pump being turned on and a flame being registered by the WhisperGen on the control panel. This shall be approximately one minute. When a flame is present the control panel will display "**Flame present**".

15. Write down the O2 start value which is about variable number 70 on the Micromon MO variables screen.

*The WhisperGen goes into a **stabilising** period next, while the burner stabilises. This will last for about a minute.*

16. At the end of the stabilising stage check that:

- the **FID Current** is greater than 0.5uA; and
- the **O2 Value** is within 200 of the O2 start value.

*(Refer to the User Manual for further information.) The WhisperGen goes into a **Heating Up** stage next.*

17. Check that the **O2 Ave Error** is less than 100.

The WhisperGen engine will be cranked when the exhaust temperature reaches between 150°C and 200°C.

18. Check that the **Gross Watts** rises to:

- a minimum of 200W five seconds after cranking; and
- a minimum of 500W five minutes after cranking.

18. Heat dump test

To check the cooling capacity of the heat dump circuit:

1. Disconnect, or turn off heat removal devices, except the marine heat exchanger or the external fan radiator.

If it is not possible to disconnect or by-pass a boiler, ensure that the water in the boiler is hot.

2. Set the **Temp Setpoint** to 45, (see **User's Manual**).
3. Run the WhisperGen at full power for a minimum of 25 minutes.
4. Write down the:

- **Coolant Temp**
- **Ext PWM** (variable 9 on the Micromon MO screen)
- **Ambient air temperature**
- **Ambient secondary coolant inlet temperature**.

*Under normal ambient air temperature (approximately 20°C), and ambient water temperature (approximately 15°C), the **Coolant Temp** shall remain below 60°C.*

5. Set the **Temp Setpoint** back to 60.
6. Stop the WhisperGen.

19. User selectable function testing

To check the Heat Manage operation:

1. Turn **Heat Manage** to on and switch on the radiators or convection heaters.
2. Start the WhisperGen.
3. Wait for the battery charge cycle to finish absorb charging.
4. Check that the WhisperGen is running in **Float charge** and is providing heat to the radiators and convection heaters. The clamp current should be greater than zero.
5. Stop the WhisperGen.
6. Turn **Heat Manage** to off.

To check the Ext. Control operation:

1. Set **Ext. Control Mode** to 2 and turn **Ext. Control** to on.
2. Close the external switch fitted to terminals 5 and 6. If no switch is fitted, place a wire jumper between terminals 5 and 6.
3. Open the external switch (or remove the wire).

The WhisperGen will stop. Under normal operating conditions, the WhisperGen runs for a minimum of one hour each time it is started by an **Ext. Control**. This prevents the WhisperGen stopping and starting every 10 minutes if it is fitted with a thermostat.

To check the Auto-charge operation, without having to discharge the battery 35% for Auto-start:

1. Make sure the WhisperGen is in **Standby** mode.
2. Set **Battery Capacity** to 100. Battery capacity is set in the hidden **Service Menu**.
3. Set **Max Battery Discharge** to 0.10.
4. Turn **Auto-charge** to **On**, from the **User Menu**.
5. Turn on some electrical loads.

When the **Batt Amp-hrs** falls to less than -10, the WhisperGen will start and begin a battery charge cycle.

The battery charge cycle can take a long time to complete. Fully charging the battery is optional during commissioning.

To stop the battery charge cycle:

1. Reset **Battery Capacity** to the correct value.
2. Reset the **Max Battery Discharge** to the correct value.
3. Stop the WhisperGen.
4. Turn **Auto-charge** to off.

If the WhisperGen is disconnected from the battery, then a full battery charge cycle is needed to reset the **Batt Amp-hrs** reading.

20. Full power operating parameters

To set the full power operating parameters:

1. Make sure that the exhaust temperature of the WhisperGen is less than 30°C.
The secondary coolant bleed function and the fan air bleed function can be used to speed up cooling of the WhisperGen.
2. Start the WhisperGen.
3. Make sure that the batteries are discharged enough and/or that the electrical load on them is enough so that the WG will run at full power. **Bulk charge** will be displayed on the control panel.
4. Check that **Gross Watts** is greater than 750 and that **Fuel Frequency** is less than 14.50 when:
 - **Runtime (minimum)** is greater than 45;
 - **Bulk charge** is displayed on the control panel;
 - **Coolant temp** is a minimum of 67 and a maximum of 72;
 - **Coolant temp** is adjusted with the **Temp Setpoint** option.
 - **Battery Volts** are a minimum of 13.8 and a maximum of 14.2V for 12V systems, or a minimum of 27.6 and a maximum of 28.4V for 24V systems.
5. Check that the engine pressure is 28 bar at a block temperature of 70°C.
6. Complete the **Full power operating parameters** of the Commissioning Checklist.
7. Stop the WhisperGen and turn off any electrical loads.

21. Completing commissioning and filling out the commissioning checklist.

To complete the commissioning procedure:

1. Start the WhisperGen and record the second **StartFuel1** value at the end of the commissioning checklist.

There will be a slight difference between the two values.
2. Complete the Commissioning Details section at the back of the **User's Manual**.
3. Complete the **Commissioning Checklist** in the Installation and Commissioning manual and return it to the Whisper Tech Limited and the distributor.

APPENDIX A: Recommended components for the coolant circuits

The following primary and secondary coolant circuit pumps are recommended. Other circulation pumps of the same, or slightly larger, capacity can be used.

Pumps should be sized to provide a minimum flow rate of 6 l/min in the primary and secondary circuits. Circuit pressures should not exceed 1 bar.

See page 11 for details of the electrical connection of the pumps.

Primary and/or secondary circuit pumps:

Johnson Pump AB Sweden

This can be used as a primary and/or secondary pump. It is a magnetically driven impeller circulation pump with low power consumption.

Pump type	Part number
CM10P7 - 1 12V	10 - 24502 – 03
CM30P7 - 1 24V	10 - 24504 – 04

Webasto Pump

This can be used as a primary and/or secondary pump.

Fab-Nr 49180 Identy-Nr 35853D 24V

12V is also available.

Alternative Secondary circuit pump – marine system

Whale Gulper 22

Use this pump in the secondary coolant circuit where the pump is not always below water level. It is a membrane pump which is self-priming. It consumes more power than an impeller circulation pump.

Secondary circuit heat dump radiator and fan (land based systems)

The following table gives recommended specifications for the heat dump radiator:

Heat rejection (Watts)	Air volume (l/s)	Connection to coolant	Dimensions (mm)
7650 @ 55°C	730	½"	547 x 344 x 418

The following table gives recommended specifications for the electric radiator cooling fan.

Size (mm)	Voltage	Max. power consumption (Watts)
Ø330	12 or 24 (as required)	130

Coolant

The primary circuit coolant must contain a corrosion inhibitor because the engine is largely manufactured from aluminium alloy.

If ethylene glycol is used as the corrosion inhibitor, a minimum of 35% undiluted glycol to 65% fresh water solution shall be used.

It is essential that the primary coolant is clean and free from debris. Foreign particles can obstruct internal coolant passages and damage the WhisperGen. Contaminated circuits should be fitted with sludge traps, upstream of the WhisperGen.

Potable water only should be used in the primary circuit to cool the WhisperGen. A corrosion inhibitor must be added.

APPENDIX B: Battery specification

A deep-cycle lead acid or gel battery with a minimum capacity of 200 ampere hours at 12V or 24V shall be used.

The battery cable size shall be a minimum of 35mm².

The maximum run length for the battery cable shall be:

- 4 metres for a 12V system; and
- 8 metres for a 24V system.

If longer battery cables are required they shall be proportionally larger in size. For example, for 8 metre cables for a 12 volt system, the cable size shall be a minimum of 70mm².

APPENDIX C: Recommendation for circuit breaker

The recommended circuit breaker is Blue Seas type 7103 (125A), 30V or similar.

A 200 amp fuse can be used with an isolating switch.